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ABSTRACT

Described is a three-year study which concentrated on determining why freshmen in college remain in or leave engineering programs. Three aspects of the study are reviewed, and one of them is analyzed in depth. The latter compares the perceptions of 2,600 freshmen while still in engineering to their status as sophomores. The categories of academic status are: (1) remained in engineering, (2) transferred into another major, (3) voluntary withdrew from school, and (4) involuntarily withdrew (dropped). The responses to an 88-item questionnaire supplied the data. T-tests, comparison of item means within categories by correlation coefficients, and discriminant function analysis used to see which items best separated students into academic status categories were used for analysis. Motivation, commitment to engineering, and strong high school records were shown to be indices of persistors in engineering. The self-image of persistors is shown to be stronger than those who leave. Differences in college entrance examination scores were not significant factors. (Author/EB)

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DIFFERENCES BETWEEN PERSISTORS AND NONPERSISTORS IN ENGINEERING PROGRAMS

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ABSTRACT

A three-year study has concentrated on learning why freshmen remain in or leave engineering programs. Three aspects of the study are reviewed and one of them is analyzed in depth. The latter compares the perceptions of 2600 freshmen while still in engineering to their academic status as sophomores.

The categories of academic status are: remained in engineering, transferred into another major, voluntarily withdrew from school, involuntarily withdrew (dropped). The responses of the freshmen to an 88-item questionnaire were compared to subsequent academic status by three analyses: comparison of item means between categories by T-test, comparison of item means within categories by correlation coefficients, discriminant function analysis to see which items best separate students into academic status categories.

Motivation, commitment to engineering, and strong high school records are indices of persistors in engineering. The self-image of persistors is stronger than those who leave, and they view their academic environment in a more positive way. Differences in college entrance examination scores were not significant among categories.

Overall, early commitment to engineering, strong vocational goals, parental moral support, strong academic credentials, and perseverance identify the persistor in engineering. Environmental supports such as quality of advising, teaching, and peer relationships have a secondary role, but are helpful for disoriented or misinformed students.

INTRODUCTION

The increasing demand for engineering graduates coupled with an insufficient number of graduating seniors has given renewed interest in the retention of students. A study was undertaken by the American Society for Engineering Education (ASEE) in 1972 to determine if possible, why baccalaureate students remain in or leave engineering programs. Details of the overall study are available in an issue of Engineering Education.[1]

The project is in its third year and has had three aspects. The first dealt with a subset of 4,000 engineering students from data of Alexander Astin. The intent was to discover similiarities between engineering dropouts and overall dropouts. Results have been published.[2]

A second aspect was to gather information on existing programs which appear to increase retention of engineering students. Dr. Andrew Pytel of the Pennsylvania State University has collated and edited information on such programs as reported by deans of ECPD-accredited schools. His report is ready for release to interested persons.

[1]Foster, R. J. and Kraybill, E. K. "Engineering Student Retention--Accidental or Planned?" Engineering Education, May 1973, p. 621.

[2]Foster, R. J. "They Who Start in Engineering," Engineering Design Graphics Journal, Vol. 38, No. 2, Spring 1974, p. 33.

The third aspect of the project is reported within this present paper. It seeks to relate perceptions of engineering students while still in engineering to their subsequent academic status. The four categories of academic status studied are: (1) remained in engineering, (2) transferred into another major, (3) voluntarily withdrew, and (4) involuntarily withdrew (academic drop). A basic question emerges: are there differences between presistors and non-persistors that can guide educators toward more effective programs?

Students were first sampled in spring 1973 when 39 schools and 2,600 freshmen participated. The students responded to an 88 item questionnaire developed for this study and their schools provided subsequent sophomore standings. A second sampling was done in fall of 1973 for 6,000 entering freshmen and 55 schools. A final sample was taken in fall 1974 for some 6,500 entering freshmen and 45 schools.

Analyses of data from spring 1973 are complete and serve as the foundation of this paper. Data analyses from fall 1973 will be done during summer 1975; that for fall 1974 during 1976.

STRUCTURE OF STUDY

The questionnaire used has scrambled items which cluster into several major groups. These include student perception of his peers, his teachers, his academic environment, his image of himself and of engineering as a profession. SAT scores and high school ranks were obtained from the schools.

Sex and race were not included in data of spring 1973, but there is hope to include them in the fall 1974 data.

The data were analyzed in several ways:

1. Paired comparisons were made between all combinations of the four categories of academic status for the means of all questionnaire items. The difference of means for each comparison was checked for statistical significance by the T test.

2. Correlations were determined for all questionnaire items within a given category of academic status. The correlation coefficients were checked for statistical significance.

3. A discriminant function analysis was made for all items across all categories of academic status.

DISCUSSION OF RESULTS

Student Expectations:

Results emerging from the data provide some interesting insights into student perceptions. Table 1 lists the expectancy of students regarding future academic status compared to the actuality of what occurred. Sample size was 2,563 students with 39 schools participating.

One notes in Table 1 that the retention rate for freshmen in school for some seven months (fall-spring) is very high: 2,219 of 2,563, or 86.5%, as measured by their return to engineering as sophomores. This is expected since much attrition occurs early in the freshman year. Subsequent sampling of freshmen done early in the freshman year will yield most probably a lower retention.

More surprising is the discrepancy between the avowed expectancies and the actualities. For example, of those who transferred, 58.9% had said they were going to remain in engineering! Of those who withdrew, 66.7% had expected to remain. These data may suggest that students are not willing to admit that major changes in their college careers are imminent.

Paired Comparisons:

It was enlightening to study the ways in which the means of questionnaire items varied between categories of academic status. The T-test detected those differences of means that were significant at the .05 level or better. Only significant differences are reported in Table 2.

The category of Remained in Engineering is compared to each of the others. Comparisons between others (e.g. categories 3 and 4) are omitted in that little significance was revealed. Also, the thrust of the study is to compare persistors with nonpersistors in engineering, not to compare those who withdraw with those who are dropped.

A Description Sheet for Table 2 is given to explain the variables. This sheet should be scanned before studying Table 2.

Some distinct results are evident in Table 2. The powerful effect of high school rank is seen, for example. Those who remain in engineering have significantly higher grades in high school. They also decided on engineering at an age

earlier than students who left engineering. This disclosure may have implications in recruitment efforts.

Those remaining in engineering found math and physics more interesting than those who left. They also found social-humanistic courses less interesting. These findings would match the intuition of many persons. Engineering students indeed seem to be number-oriented rather than social-issue oriented in terms of course interests.

However, these same students rated social-humanistic courses less difficult than students who transferred. Could it be that engineering students who remain grasp concepts faster than those who leave?

Financial Resources is a significant variable between those remaining in engineering and those voluntarily withdrawing. This reflects the well known cause for some withdrawals from school.

The remaining variables of Table 2 represent clusters of questionnaire items. Variables 7, 8, 9, and 10 are significant across all combinations of comparisons. Only the cluster, Perceived Nature of Engineering Students, breaks the pattern. Here only those who experienced an involuntary withdrawal (academic drop) had a more negative view of their student peers. These students dropped from engineering tended to feel, while still in engineering, that

engineering students did not have a strong group spirit and did not enjoy a social life as full as other students.

Cluster variables 8, 9, and 10 had many differences of means that were significant. To amplify these comparisons, the individual items within the clusters are listed in Table 3 when significant. The items from the questionnaire are grouped into arbitrary divisions to assist reading.

One sees that students who leave engineering appear to have a sense of alienation, inadequacy, and lack of motivation. These items relate to personal aspects which a student may not make explicit in classroom performance. Lack of support, whether from peers or faculty, is felt by leaving students.

Some who leave engineering are in academic difficulty, as a few of the items emphasize. The poor study habits expressed would not seem to enhance academic excellence. Motivation is no doubt a factor in achievement in engineering programs, in that college entrance examination scores (SAT's and ACT's) did not vary significantly across categories of academic status. People leaving engineering had done as well on math and verbal SAT scores as those remaining.

Other items having nonsignificance in differences of means were age of students in engineering and items in clusters relating to excellence of teaching. Some items within nonsignificant clusters were significant, however, and are listed in Table 3.

Correlations within Categories:

The second major analysis provides statistically significant correlations between the means of any two items within a given category of academic status. This information may help answer such a question as: do engineering persistors correlate positively their self image with feelings about their program? Or conversely, do students learning engineering having a negative perception of the program also have a negative self image?

Table 4 lists those items which are significant at the .05 level and which also involve at least students remaining in engineering. Some correlations may be considered "obvious". It is well known, for example, that high school rank and SAT scores have positive correlations.

Some correlations are not so obvious. Note that Self Image and Age Decided on Engineering correlate positively. That is, when a person decides to major in engineering early, he is apt to have a strong self-image. We have already seen that persons who elect engineering early tend to persist better than those deciding later.

The high interest/low difficulty correlation with mathematics tends to be readily accepted. (Low interest/ high difficulty would also be valid). However, the high Interest in Math coupled with low rapport with the Engineering Program Environment is not expected. The latter says that students who have a low interest in math tend to favor the engineering program environment, and vice versa. Does this

reveal something about the way mathematics is taught to engineering freshmen?

The correlation matrix of Table 4 reveals many significant correlations for the various cluster items. For one, Self Image correlates positively with all other clusters. This suggests that when one sees himself in a positive way, the world around looks wholesome, too. Conversely, if one is frustrated and unhappy, life outside of self appears sour. Educators could postulate that those elements that debilitate the self image of a freshman engineer may erode his perception of the entire college experience.

Experience with teachers correlates heavily with other clusters. Pleasant and productive relationships with teachers correlate positively with a strong self image and a favorable outlook on the program and surrounding environment. The strong correlation of engineering teachers to other teachers, however, shows that the questionnaire did not discriminate well between these two clusters.

Correlations of Table 4 provide information only for within categories of academic status, and they usually apply to all categories. The difference between categories shown in Table 2 may be of more real value if programs are studied with the goal of increasing retention.

Discriminant Function Analysis:

A final analysis of data used the process of discriminant function analysis. The separate T tests and correlations

previously performed are useful, but they do not detect overlapping effects among variables. The extent to which results duplicate each other is not known.

Discriminant function analysis provided those questionnaire items which best discriminated among the four categories of academic status. That is, listed first was the single item whose response by freshmen while still in engineering separated them best in the sophomore year in terms of academic status. Listed next was the second best item which discriminated among categories. This process continued through the 40 items selected for analysis. The direction or sign of discrimination of an item is found by observing the means across the four categories.

One sees in Table 5 that items which relate to a student's commitment to engineering discriminate best. Those who remain in engineering are strongly motivated, have a good high school rank, and want the economic value of the degree. Therefore, those who remain tend to have a solid academic background and to be vocationally oriented.

They are also willing to exert the effort needed to graduate in engineering and may desire a master's degree. They receive moral support from parents and have made an early-age commitment to engineering.

Subsequent items of importance relate less to personal commitment and more to the academic environment. Students remaining in engineering believe that knowing the correct

answer in tests is not more important than defending a point of view. They believe grades received are an honest indication of their ability (because their grades are higher?). They are more satisfied with faculty advising than those who leave. Their reaction to teaching assistants and interest in other academic fields is somewhat mixed relative to students leaving engineering.

Beyond the twelve items listed in Table 5, subsequent items of the 40 total selected did not further reduce the approximate F ratio to any extent. They are therefore not listed.

The major finding shown in Table 5 is that factors that lead to a personal commitment to engineering on the part of a student seem to outweight those elements contributing to a supportive, pleasant environment. Those educators of the "elitest" school would support this finding, perhaps with the well-known statement, "You can't hold a good student down". On the other hand, educators laying stress on supportive environments could say that factors outside a student's own dedication are of influence, especially in the case of disoriented, frustrated or misinformed students.

The discriminant function analysis also indicated the extent of difference among academic categories. This was done by multiplying the mean response for each item of a given category by its discriminant score (or "weight"). These products were summed for the category. All four categories received

this treatment. The result was these scores:

Category	1	2	3	4
Score	135.9	146.9	149.3	161.9

One sees that students who transfer into another major (2) or withdraw coluntarily (3) group rather closeby. Conversely, those who remain in engineering (1) or who are asked to leave (4) are distinct groups. It is difficult to draw hard conclusions, but perhaps it is safe to state that in actuality there are only three principal groups of students: those who remain in engineering, those who make up their own minds to leave engineering either by transferring or withdrawing, and those who are told to leave. An interesting further study would be to discover why students who transfer or voluntarily withdraw appear to have similar characteristics.

It is the desire of this report to evoke discussion among persons concerning aspects of student retention in engineering. More importantly, it is strongly wished that individual faculties and deans can use the findings to evolve more effective programs for their particular situations.

Table 1

COMPARISON OF STUDENT EXPECTANCY AND ACTUALITY BETWEEN SPRING 1973 FRESHMAN STATUS AND FALL 1973 ACADEMIC STATUS

	Expectancy in Spring 1973				
Fall 1973 Status	Remain in Engineering	Transfer	Voluntary Withdraw	Academic Drop	Sample Size
Remained in Engineering	95.6%	3.5%	0.5%	0.4%	2219
Transferred	58.9%	38.3%	1.4%	1.4%	141
Withdrew	66.7%	13.6%	19.1%	0.6%	162
Dropped	58.5%	17.1%	17.1%	7.3%	41
					2563

Variable		Description
1.	H.S. RANK	High school rank where 1 = 1st fifth, 5 = 5th fifth
2.	DECIDED ON ENGRG	Time at which student decided on engineering: 1 = 10 grade or earlier. . .5 = still undecided.
3.	T THRU 6	Interest and Difficulty in various subject areas: 1 = most interesting or difficult 5 = least interesting or difficult
11.	FINANCIAL RESOURCES	A low mean indicates a student's finances were sufficient to permit concentration on students.

Cluster Groups: Variables 7,8,9,10

Questionnaire items were clustered for some analyses. Low means indicated student support for the statements within the clusters below:

7. Perceived nature of engineering students: Engineering students have self-control, a strong group spirit, a modest social life, and dislike routine assignments. Economic value of a degree is secondary.

8. Self Image: Students are well motivated; have good study habits and academic backgrounds. They are comfortable with engineering students and seek academic advice more from friends than teachers. Outside interests do not compete strongly for their time. Parents support, but do not pressure them. They are satisfied with their grades, their ability, and the worth of the effort. Outside of engineering, they would be unhappy. Important is the expectation of a master's degree and a secure career.

9. Image of engineering: Engineers have self-discipline and tend to be conservative, working with things more than people. Engineering problems have more than one right answer, but competence in math is essential to being successful in engineering, a field not particularly suited to solving social problems. The student understands the functions of engineering and expects good employment opportunities.

10. Engineering program environment: The student finds math not difficult, and the program one to develop clear thinking. Other fields do not strongly interest him. The program material meets his expectations, with sufficient engineering courses the first year. The program is not rigid, the work load is reasonable, and the atmosphere is friendly.

Table 2 - COMPARISON OF MEANS

BETWEEN CATEGORIES OF ACADEMIC STATUS

VARIABLE	1 REMAINED IN ENGR	2 TRANSFERRED FROM ENGR	3 VOLUNTARILY WITHDREW	4 INVOLUNTARILY WITHDREW	COMPARISONS HAVING SIGNIFICANCE col 1&2	1&3	1&4
1. H.S. RANK	1.55	2.01	1.76	1.91	*	*	*
2. AGE DECIDED ON ENGRG	2.34	3.09	2.68	2.76	*	*	
3. MATH INTEREST	2.26	2.62	2.46	2.81	*	*	*
4. SOCIO-HUM INTEREST	3.65	3.11	3.32	2.93	*	*	*
5. PHYSICS INTEREST	2.52	2.88	2.69	2.92	*		*
6. SOCIO-HUM DIFFICULTY	2.95	2.61	2.95	2.67	*		
7. PERCEIVED NAT ENGRG STUDENTS	2.92	2.96	2.96	3.13			*
8. SELF IMAGE	2.76	3.02	2.95	3.14	*	*	*
9. IMAGE OF ENGRG	2.41	2.47	2.46	2.25	*	*	*
10. ENGRG PROGRAM ENVIRONMENT	2.90	3.09	3.03	3.17	*	*	*
11. FINANCIAL RESOURCES	2.66	2.71	2.89	2.83		*	

NOTE: A VARIABLE IS LISTED ONLY IF THE DIFFERENCE OF MEANS BETWEEN CATEGORIES IS SIGNIFICANT AT THE .05 LEVEL OR BETTER

TABLE 3

STATEMENTS OF SIGNIFICANCE WHEN COMPARING

MEANS BETWEEN CATEGORIES OF ACADEMIC STATUS

Level of significance = .05 or better

Compared with students remaining in engineering, those who transferred into another major:

Informational Area	1.	did not understand the differences among the research, development, production, and marketing functions of engineering.**
	2.	believed there would not be good employment opportunities in engineering upon graduation.**
Academic Area	1.	did not believe they had sufficient scholastic ability for engineering.
	2.	found college mathematics more difficult.***
	3.	found the course load "too much, too fast".**
	4.	found graduate assistants not good as teachers.*
Motivational and Attitudinal Area	1.	were not strongly motivated to be engineers.**
	2.	were not interested in academic fields outside of engineering.***
	3.	had outside interests competing for study time.
	4.	did not have well disciplined study habits.**
	5.	worried about motivation to do the work required in engineering.***
	6.	found the atmosphere in engineering to be impersonal.**
	7.	found the engineering program to be too rigid and inflexible.
	8.	tended to believe there is one right answer to most engineering problems.
	9.	tended to disbelieve that engineering education helps one think clearly and logically.*
	10.	did not believe it worth the study required to graduate in engineering.**
	11.	believed engineering students desire a degree for its economic value.

12. were more comfortable with students in other disciplines.**

13. would not be as unhappy if they transferred out of engineering.*

14. had parents less enthusiastic about engineering.

* also for voluntary withdrawals

** also for voluntary withdrawals and involuntary withdrawals

*** also for involuntary withdrawals

Compared with students remaining in engineering, those who voluntarily withdrew:

1. did not find advising by engineering faculty helpful.

2. found the atmosphere in engineering to be impersonal.

3. found upperclassmen to play an inactive role in helping new students adjust.

4. did not prefer to work alone on math problems.

5. found sufficient courses taught in an innovative way.

6. did not find the material covered in the engineering program to be that expected (also true for involuntary withdrawals).

7. did not believe grades reflected their ability (also true for involuntary withdrawals).

TABLE 4 - MATRIX OF ITEMS HAVING SIGNIFICANT CORRELATIONS WITHIN SPECIFIC ACADEMIC STATUS CATEGORIES

Item	Correlation Matrix				
	Nature Engrg Students	Self Image	Engr Prog Environment	Engrg Tchrs	Other Tchrs
Self Image	1,2,3,4				
Image engrg		1,2,3			
Engrg program environment	1,3,4	1,2,3,4			
Engrg tchrs	1,2,4				
Other tchrs	1,3,4	1,2,3,4	1,2,3,4	1,2,3,4	
College environment	1,2,3,4	1,2,3	1,2,3	1,2,3,4	1,2,3,4

Other Significant Combinations

SAT Verbal - SAT Math: 1,2,3,4

High School Rank - SAT Math & SAT Verbal: 1,2,3,4

Self Image - Age Decided on Engrg: 1,2,4

Difficulty with Math - Interest in Math: -1, -4

Interest in Math - Engrg Program Environ: -1, -2, -3, -4

NOTE: 1 = students remaining in engineering

2 = students who transferred into another major

3 = students who voluntarily withdrew

4 = students who involuntarily withdrew (dropped)

A minus sign denotes a negative colleration coefficient. No sign denotes a positive correlation coefficient. All comparisons are significant at the .05 level or better.

TABLE 5

QUESTIONNAIRE ITEMS THAT BEST DISCRIMINATE

AMONG CATEGORIES OF ACADEMIC STATUS

(In Descending Order of Importance)

	Item	Means for Category			
		1	2	3	4
1.	I am strongly motivated to be an engineer.	2.26	2.95	2.68	2.76
2.	High school rank.	1.55	2.01	1.76	1.91
3.	Most engineering students want a degree for its economic value.	3.50	3.66	3.51	3.69
4.	It is well worth the effort to be able to graduate as an engineer.	2.02	2.32	2.32	2.38
5.	I expect to earn at least a master's degree in engineering.	2.87	3.39	3.12	3.26
6.	My parents are enthusiastic about my being in engineering.	2.17	2.39	2.27	1.95
7.	I decided to become an engineer at age: (5 listed)	2.34	3.09	2.68	2.76
8.	In most exams the emphasis is on knowing the correct answers rather than on being able to defend a point of view.	3.62	3.56	3.46	3.79
9.	Grades received for work done to date are an honest reflection of my ability.	3.28	3.40	3.51	4.10
10.	There are academic fields outside of engineering that strongly interest me.	3.89	4.30	3.99	4.21
11.	Graduate assistants I have had as teachers were generally excellent.	3.20	2.99	3.03	3.14
12.	The advising provided by engineering faculty is personal and helpful.	2.79	2.90	2.95	2.95

NOTE: Means are from a 5 part scale where 1 = strongly agree, 5 = strongly disagree, except for item 2 where 1 = 1st fifth, 5 = 5th fifth, and for item 7 where 1 $\leq$ 10th grade, 5 = still undecided.